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ABSTRACT

The increased number of marginal aptitude trainees inducted into the Army has created the need for adequately and efficiently training these men. This report presents the finding of research that compared high and low aptitude men--classified on the basis of scores from the Armed Forces Qualification Test (AFQT)--on two form discrimination tasks that required both intramodal and intermodal functioning. One experiment required the men to make a simultaneous discrimination of meaningless forms, using vision and touch. A second experiment repeated the first and introduced a delay period between the presentation of the standard and comparison stimuli. The results showed that, as a group, high aptitude men performed consistently better than low in both experiments. Analysis of verbal reports of the subjects indicated that the majority of the high aptitude men used higher order processing or learning strategies that enabled them to make more accurate matches. The results indicated that training in the organization of stimulus inputs into mediational units holds promise as an approach to helping low aptitude people improve their organizational and information processing skills. (Author)

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Technical
Report
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Aptitude Level and Performance on Intramodal and Intermodal Form Discrimination Tasks

Gary Kress

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March 1973

Prepared for

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Washington, D.C. 20310

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Aptitude Level and Performance on Intramodal and Intermodal Form Discrimination Tasks

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Presidio of Monterey, California
HUMAN RESOURCES RESEARCH ORGANIZATION

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

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FOREWORD

The research reported here is part of an overall research effort under Work Unit SPECTRUM to develop procedures for selecting and organizing training content and training methods to achieve more effective training across the spectrum of aptitude. The work reported here was part of Work Sub-Unit SPECTRUM III. The purpose of the research was to explore the relationship between aptitude level and sensory-perceptual performance.

The research was conducted during August-November 1970, by HumRRO Division No. 3, Presidio of Monterey, California. Dr. Howard H. McFann is Director of the Division. Military support was provided by the U.S. Army Training Center Human Research Unit, Presidio of Monterey. COL Ullrich Hermann was Chief of the Unit during the conduct of this study. The research was conducted by SP4 Gary Kress under the supervision of Dr. John E. Taylor, Work Unit Leader.

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Meredith P. Crawford
President
Human Resources Research Organization

SUMMARY AND CONCLUSIONS

MILITARY PROBLEM

The increased number of marginal aptitude trainees inducted into the Army for the past few years has created the problem of adequately and efficiently training these men. The purpose of Work Unit SPECTRUM, Sub-Unit III, has been to develop training strategies to help solve this problem. It is known that low aptitude Category IV personnel are more difficult to train, when compared as a group, than high aptitude personnel, and that more Category IV persons come from poor social, economic, and educational backgrounds than men in higher categories do. These background factors probably contribute greatly to learning and motivational deficiencies in Category IV people.

It has not been adequately determined whether poor learners might also possess sensory-perceptual deficiencies, as opposed to more cognitive deficiencies, which could influence their learning abilities. One way of providing information on this question is to compare high and low aptitude trainees on a sensory-perceptual task to see whether there are any differences on this level.

RESEARCH PROBLEM

This report presents the findings of research that compared high and low aptitude men—classified on the basis of scores from the Armed Forces Qualification Test (AFQT)—on two form discrimination tasks that required both intramodal and intermodal functioning. One experiment required the men to make a simultaneous discrimination of meaningless forms, using vision and touch. A second experiment repeated the first and introduced a delay period between the presentation of the standard and comparison stimuli.

METHOD

The first experiment used 20 high aptitude trainees (AFQT 90-100) and 20 low aptitude trainees (AFQT 10-20). Each man performed the same task, which consisted of two intramodal and two crossmodal form discriminations. The intramodal conditions were visual standard - visual comparison and tactual standard - tactual comparison. Each man examined the standard stimulus with one modality and compared it with four comparison stimuli, with either the same or a different modality, to tell which of the comparisons was identical to the standard. Both the number of errors and the time needed to make the comparison were recorded.

In the second experiment, 30 high and 30 low aptitude men were used. The conditions were the same as in the first experiment, except that 1-second, 5-second, or 10-second delay periods were inserted between the presentation of the standard and the presentation of the comparison. The subject had to tell whether the single comparison figure was the same as or different from the standard. Again, both time and error data were recorded for each man.

RESULTS

The results showed that, as a group, high aptitude men performed consistently better than low in both experiments. In Experiment I, the low aptitude group produced more overall errors and took more time than the high aptitude group. There were no interactions between the aptitude levels and the conditions.

Experiment II showed that, as a group, low aptitude men committed more errors but took significantly less study time than high aptitude men. The delay conditions were not significantly different for either group, and again there were no interactions between the groups and the conditions.

Analysis of verbal reports of the subjects indicated that the majority of the high aptitude men used higher-order processing or learning strategies that enabled them to make more accurate matches.

CONCLUSIONS

In a form discrimination task in which the standard and comparison stimuli are presented simultaneously:

(1) High aptitude men generally perform faster and more accurately than low aptitude men.

(2) With only minor differences, both high and low aptitude men are able to perform an intermodal discrimination task in which the standard stimuli are presented via one modality (either vision or touch) and the comparison stimuli are presented via the other modality.

In a form discrimination task in which a time delay is introduced between the presentation of the standard and comparison stimuli:

(1) High aptitude men take more time to study the standard stimuli.

(2) There are no differences between high and low aptitude men in the amount of time they take to make a match.

(3) In terms of match accuracy, high aptitude men perform significantly better than those of low aptitude.

(4) High aptitude men, for the most part, use their longer study time to organize stimulus inputs into mediational units. This, presumably, contributes to their superior match accuracy. Low aptitude men, on the whole, do not organize stimulus inputs into such mediational units, which probably accounts for their impaired match accuracy. There are no significant differences between high and low aptitude subjects in the intermodal matching tasks.

(5) Training in the organization of stimulus inputs into mediational units, on the part of low aptitude people, appears to hold promise as one approach for improving organizational and information processing skills.

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Aptitude Level and Performance on Intramodal and Intermodal Form Discrimination Tasks

Chapter 1

INTRODUCTION

BACKGROUND

In October 1966 the Department of Defense, under Project 100,000, lowered to the legal minimum the mental standards for induction into the Army. This minimum was set by Congress in 1951 as an Armed Forces Qualification Test (AFQT) score of not less than 10. The AFQT is a test that measures verbal and arithmetic reasoning ability, spatial relations, and tool functions, and its scoring system is in the form of percentile equivalents. Examinees who score between 10 and 30 are classified as Mental Category IV, and those who score between 10 and 20 are classified as marginal aptitude trainees. As a result of the decision to lower the mental standards for inductees, it has been estimated that up to 25% of the new inductees into the Army would be marginal aptitude trainees.

The purpose of Work Unit SPECTRUM and, specifically, Sub-Unit III, is to develop new instructional methods and materials that will be optimally effective in teaching military tasks to personnel found along the entire spectrum of aptitude. In earlier SPECTRUM work (1), experience in the laboratory in teaching tasks such as map reading, military time, phonetic alphabet, and switchboard operation showed that high aptitude trainees (AFQT 90-100) are able to learn most cognitive and motor tasks quickly and with a minimum of errors, regardless of the methods and materials used for training. The majority of Category IV trainees, on the other hand, operate well only under a limited set of conditions, such as one-to-one instruction, small-step acquisition, and optimal performance feedback, and even then the performance of some is not equivalent to that of high aptitude people.

Previous studies by Fox, Taylor, and Caylor (1) and Goffard, Showel, and Bialek (2) show that the performance of Category IV trainees as a group is consistently—although sometimes only slightly—below that of trainees in other mental categories. These differences become especially pronounced in tasks that require verbal or cognitive abilities. This is not surprising, since the AFQT measures primarily verbal and cognitive abilities and, therefore, a low AFQT score would predict poor performance in these areas. What is surprising, however, are the findings by Fox, Taylor, and Caylor (1) and Fox (3), which show that in simple and choice visual monitoring tasks, low aptitude men generally were slower to respond, more variable in their responses, and less accurate than higher aptitude subjects. These findings seem to indicate that even on a basic sensory-motor level, requiring limited cognitive performance, low aptitude men do not perform as well as higher aptitude men.

There are few studies that relate mental aptitude, as measured by the AFQT, to sensory-perceptual performance. A number of studies, including Berkson (4) and Dickerson (5), have compared mentally retarded with normal subjects on reaction time studies and have found that the retarded perform more slowly. On the other hand, Hermelin and O'Connor (6) have reported that retarded individuals were superior to normal ones in tactual recognition of letter shapes, which might imply that retarded people develop particular perceptual skills to compensate for deficiencies in verbal and cognitive areas. In any case, marginal aptitude people, although they exhibit deficiencies in verbal and cognitive skills, can not be considered, as a group, to be mentally retarded in the clinical sense.

PURPOSE OF THE STUDY

The purpose of the present set of experiments was to examine the relationship between mental aptitude level (as measured by the AFQT) and performance on a basic sensory-perceptual task. It was hoped that the particular tasks chosen would allow the experimenter to determine whether perceptual deficiencies existed in low aptitude men, and if they did, to determine in what way they existed. Intermodal and intramodal form discrimination tasks, using vision and touch, were chosen.

Form discrimination across and within visual and tactual modalities has been demonstrated in a number of studies (e.g., Gaydos, 7; Eastman, 8; Lobb, 9; and Cashdan, 10). Basically, these tasks require that a subject examine or learn the shape of a standard figure with one modality and subsequently discriminate this form from similar comparison figures, using either the same or a different modality. If the discrimination is made simultaneously—that is, both the standard and comparison figures are examined at the same time—it can be presumed that the higher mental processes, such as verbal coding, mediation, and memory, needed to perform the task would be limited. However, if the standard figure is removed before the comparison figure is presented, then a memory component, which would allow for verbal or symbolic mediation, is necessarily added to the task.

The experiments described above have, for the most part, used a "normal" experimental population. The sample drawn from this population usually consisted of adults with average or above average mental aptitude. The findings consistently showed a strong superiority for vision on the within-modality tasks; that is, when both components of the task were performed visually, it always resulted in better performance than any other combination of modalities. The studies are divided, however, when it comes to cross-modal transfer. Some studies show a greater transfer from vision to touch, while others show just the opposite, a greater transfer from touch to vision. Typically, the tactual within-modality tasks resulted in the poorest performance. At variance with the main findings of these studies is a study by Garvill and Molander (11). which showed that within-modality form discrimination is superior to cross-modal form discrimination.

The experiments to be reported were basically the same as those described above. That is, a subject was given a standard form to examine with one modality and subsequently had to match it with similar forms, using either the same or a different modality. The parameters of the experiment, pertaining to stimulus presentation time, were modified with the intention of creating more equivalence between vision and touch in the amount of time needed to examine a stimulus. The first experiment consisted of a simultaneous discrimination task that provided data on the basic sensory-perceptual functioning of high and low aptitude men. The second experiment, delayed matching, examined the memory and mediational abilities of the two groups.

These experiments were designed to provide information on the extent to which low aptitude people are deficient in perceptual or information processing abilities. Of interest were the questions (a) Would low aptitude men be able to integrate information from two different modalities in the cross-modal tasks? (b) Would there be any differences between high and low aptitude people in their ability to mediate information about forms across time?

Chapter 2

RESEARCH APPROACH

GENERAL METHODOLOGY

In comparing visual and tactual form perception, care has to be taken that the stimuli used and their method of presentation not be biased in favor of one or the other modality. Gibson (12) points out that visual perception is said to be based on the "figure-ground" phenomenon in which the entire contour of a form is registered simultaneously, whereas tactual perception, in most cases, involves separate or successive impressions. This does not deny that in most cases of visual perception, voluntary and involuntary eye movements also lend a successive aspect to visual perception. It does point out, however, that a visual form discrimination task can be performed much more quickly than a tactual form discrimination task. This is especially true in the case of multiple stimuli in which a comparison of the different figures in an array can be made in a single scan, which would not be possible to do tactually.

The present experimental tasks tried to equate the two modalities in terms of the amount of information available and the length of time it was available. The first objective was met by presenting the comparison figures one at a time to both the visual and the tactual modality (some previous experiments have presented all the comparison figures simultaneously, thus making the visual discrimination task somewhat easier than the tactual task). The second objective was met by letting the subject control how long he examined both the standard and the comparison figures (most studies have allowed the same amount of time for both visual and tactual examinations). By allowing the subjects to study the figures for as long as they wanted, two assumptions could be made: (a) that there was sufficient time for both modalities to extract the required information, and thus that the task did not favor either modality in this respect; (b) that differences in errors between highs and lows would not be due to one group working faster than the other group.

The major independent variables in both experiments were the two intermodal and two intramodal conditions. The combinations of vision and touch were as follows: visual standard - visual comparison (V-V), visual standard - tactual comparison (V-T), tactual standard - visual comparison (T-V), and tactual standard - tactual comparison (T-T). Th major dependent variables in both experiments were the number of errors produced in each condition and the amount of time taken by each subject to make a discrimination.

SUBJECTS

The subjects for both experiments were male Army recruits in their last two weeks of Basic Combat Training (BCT) at Fort Ord, California. At the time the experiments began, two companies (about 400 trainees) were available as potential subjects. Trainees' records were screened to identify high aptitude (AFQT 90-100) or low aptitude (AFQT 10-20) men. Essentially all trainees who fell into either category, except those who were unavailable for administrative, medical, or other reasons, were used in the experiment.

The first experiment used 40 men—20 highs (AFQT 90-100) and 20 lows (AFQT 10-20). The high aptitude group ranged in age from 19-25 years with a mean of 21.6; their mean AFQT score was 93.6. The low aptitude people ranged in age from 17-25 years with a mean of 20.2; their mean AFQT score was 16.6.

The second experiment used an additional 60 men, 30 highs and 30 lows. The high aptitude men in this group ranged in age from 19-26 years with a mean of 21.6, and had a mean AFQT score of 94.5. The low aptitude men ranged in age from 18-29 with a mean of 20.5, and had a mean AFQT score of 16.2.

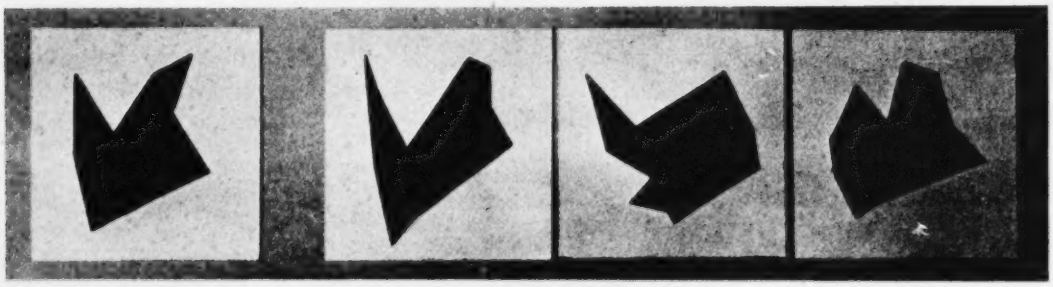
STIMULUS MATERIAL AND APPARATUS

The stimuli used in both experiments were random forms, generated so as to equate them for similarity according to the method of Lawrence and La Berge (13). Using this method, 10 pairs of random numbers were plotted on graph paper with two units to the inch. The 10 points were connected and the enclosed area formed the primary, or standard, figure. Next, shapes somewhat similar to the primary figure were generated by moving each point in a random direction, according to randomly selected integers from 0 to 360 degrees. For each set of figures there were two identical standard figures and three transformations of the standard.

In Experiment I, both easy and difficult figures were used. "Easy" figures were those whose points were moved 1/2 inch to form the transformation. For "difficult" figures the points of the standard figure were moved only 1/4 inch to form the comparison. In general, the greater the distance that each point was rotated, the less similar it was to, and the more easily it was discriminated from, the standard. Figure 1 provides a set of easy-to-match figures, and difficult-to-match figures are shown in Figure 2.

All the figures were transferred to 1/4 inch wallboard, cut out and painted flat black. They were then mounted individually on identical 6 inch x 6 inch pieces of 1/4 inch plywood painted flat white.

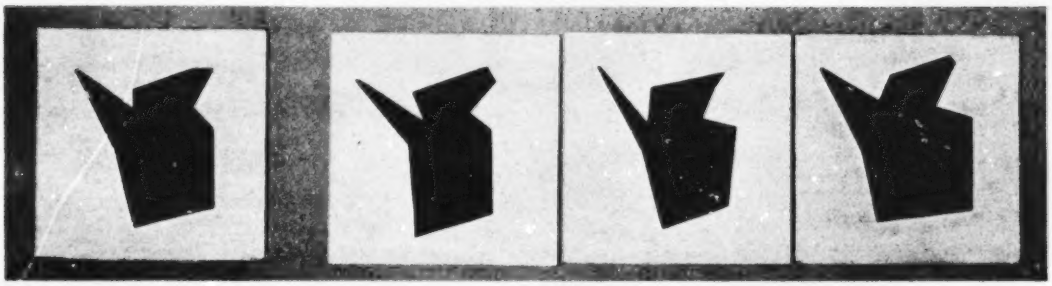
A Set of Easy Random Shapes



NOTE: The standard form is on the left, followed by its three transformations.

Figure 1

A Set of Difficult Random Shapes

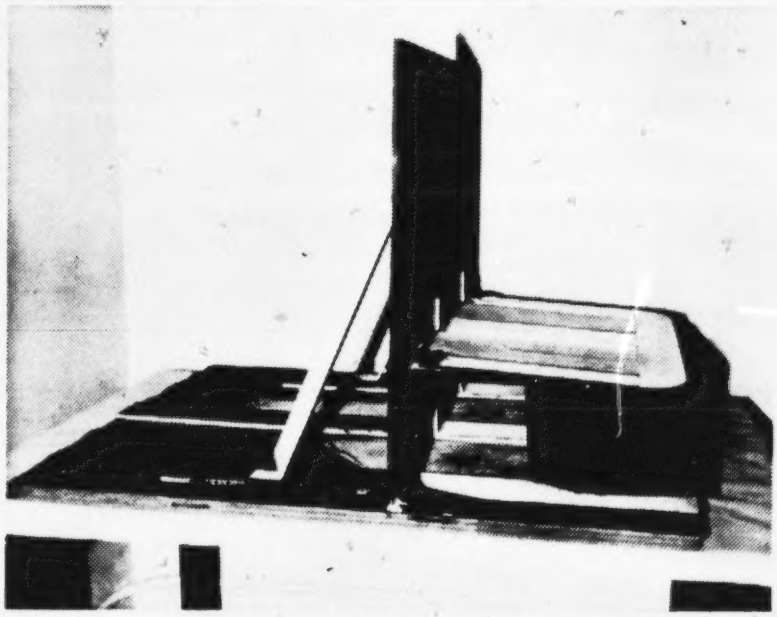


NOTE: The standard form is on the left, followed by its three transformations.

Figure 2

The apparatus used in both experiments is shown in Figure 3. It consisted of a horizontal piece of plywood, 2 feet wide and 3 feet long, divided in the middle by a vertical piece of plywood 2 feet square. Four rectangular holes, 2 inches by 6 inches, were cut out of the divider, two along the base, separated by 3 inches, and two 5 inches above the base. These holes allowed the passage of stimulus figures to the subject's side of the apparatus. On that side, a platform 1 foot x 1 1/2 feet was fastened to the divider approximately 5 inches above the base. A black curtain was hung around the edge of the

Apparatus Used in Both Experiments



NOTE: The subject sat on the right side of the apparatus.

Figure 3

platform to hide figures presented through the lower part of the divider. Channels 6 inches wide were mounted on the platform and the base so that the figures would be locked into place when examined by the subjects. When the figures were examined visually, both the standard and/or the comparison were pushed through the upper holes and rested on the platform. For tactual examination, the figures were presented through the lower holes and the man had to reach underneath the curtain to feel them. The curtain obscured all figures presented in this manner.

Time measures were recorded in both experiments by electric timers that were accurate to 1/1,000 of a second. In the first experiment, the experimenter depressed a microswitch with his foot to record the amount of time each subject spent comparing each standard figure with the comparisons. In the second experiment, two timers were used, one to record the time spent studying the standard and the other to record the time spent trying to make the match. A stop watch was used in the second experiment to measure the delay period between the removal of the standard and the presentation of the comparison stimuli.

Chapter 3

EXPERIMENT I

METHOD

Experiment I explored the perceptual abilities of high and low aptitude subjects on an intramodal and crossmodal form discrimination task. All the subjects examined a standard form either visually or tactually, and their task was to match this form with its twin in a series of four comparison figures. The comparison figures were presented in either the same modality or a different modality. All the figures were presented in the same orientation and the subject used his preferred hand to examine the figures in the T-V and V-T conditions. The matches were made simultaneously, that is, the standard form and one of the comparison forms were always present for immediate cross-reference and feedback. Very limited, if any, mediational or memory abilities were involved in this task; it involved performance on a sensory-perceptual level. The experimenter recorded the time it took the subject to examine all four comparison figures on each trial.

Twenty-four sets of stimuli were used for each subject--12 sets easily discriminable, and 12 more difficult to discriminate. The difficulty level of the figures depended on their method of construction, as outlined earlier. Each subject received three trials under each of the four conditions: V-V, T-V, V-T, and T-T. The order of presentation of the stimulus sets was counterbalanced across conditions and subjects. The order of presentation of the stimuli within a set was random for each subject.

The major independent variables were incorporated into a 2(subjects) x 2(difficulty level) x 4(conditions) factorial design with repeated measures on the difficulty and conditions factors. The dependent variables were the number of incorrect discriminations in each condition and the total time taken per set to make a match.

The questions of interest in this experiment were: (a) Would high and low aptitude subjects do equally well in terms of total errors? (b) Would the two groups be similar in the time used to make each match? (c) In terms of the first two measures, would there be any qualitative differences in how high and low aptitude subjects are able to utilize inputs from two different modalities?

RESULTS

Table 1 shows a negligible number of errors in matches made (24 per subject), which is not surprising since the subjects were allowed unlimited time. As shown, the V-V condition was the easiest—no subject made an error—while the T-T condition was the most difficult. This was especially applicable for the low aptitude subjects, who produced a total of 27 errors in this condition compared to 10 for the high aptitude people. For all practical purposes, the two intermodal conditions (T-V and V-T) are equally difficult for both groups.

Because of the limited number of errors observed, analysis of variance of the error data was judged inappropriate; however, the test for significance between two proportions showed that the low aptitude group produced significantly more total errors than the high aptitude group ($p<.001$). The same test limited to the T-T condition again showed that the low aptitude subjects made significantly more errors than the highs ($p<.001$).

Table 1

Total Errors for Both Groups: Experiment I

Condition		Category I Men (N=20)			Category IV Men (N=20)		
Standard	Comparison	Easy	Difficult	Total	Easy	Difficult	Total
Visual	Visual	0	0	0	0	0	0
Tactual	Visual	2	2	4	1	9	10
Visual	Tactual	2	4	6	1	7	8
Tactual	Tactual	3	7	10	11	16	27

Table 2

Time Scores for Both Groups as a Function of Conditions and Difficulty Level: Experiment I (Minutes)

Condition		Category I Men				Category IV Men			
		Easy		Difficult		Easy		Difficult	
Standard	Comparison	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Visual	Visual	.20	.07	.24	.02	.26	.07	.31	.08
Tactual	Visual	.58	.26	.70	.37	.72	.23	.96	.38
Visual	Tactual	.72	.29	.90	.31	.88	.24	1.15	.39
Tactual	Tactual	1.15	.63	1.56	.65	1.35	.52	1.73	.74

Table 3

Analysis of Variance for Time Scores: Experiment I

Source	*df*	*MS*	*F*	*p*
Between Subjects				
Groups (A)	1	2.17	3.08	<.10
Error-A	38	.71		
Within Subjects				
Difficulty (B)	1	3.53	72.02	<.001
AB	1	.05	<1	
Error-B	38	.05		
Conditions (C)	3	19.56	152.81	<.001
AC	3	.09	<1	
Error-C	114	.13		
BC	3	.42	13.65	<.001
ABC	3	.02	<1	
Error-BC	114	.03		

Mean Response Times per Condition and Difficulty Level for Both Groups

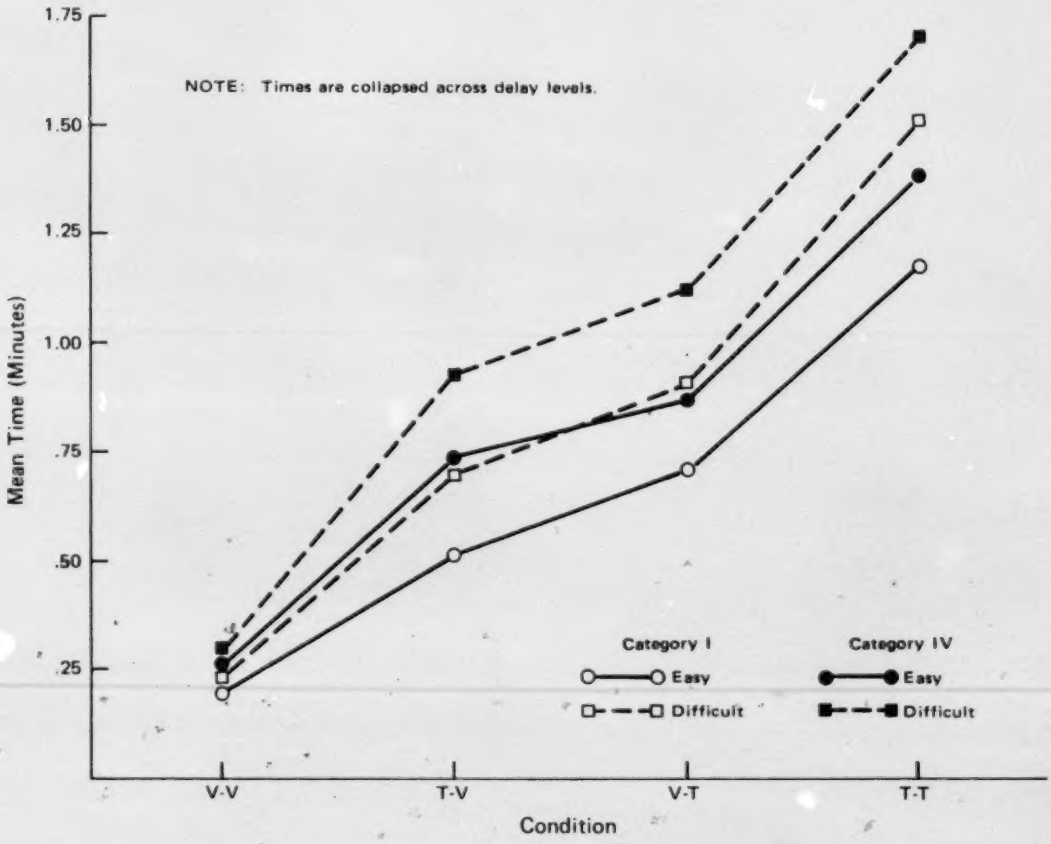


Figure 4

The mean times and standard deviations of the two groups for both difficulty level and conditions are shown in Table 2 and presented graphically in Figure 4. The summary for the analysis of variance of the time scores is presented in Table 3. This analysis shows a difference, although only marginally significant, between high and low aptitude subjects on the amount of time they took to make the discriminations. Low aptitude men took more time than highs to perform the task ($p<.10$). There was a significant main effect for both difficulty level ($p<.001$) and conditions ($p<.001$). The difficulty level by conditions interaction (BC) was also significant ($p<.001$).

Since the BC interaction was significant, tests on the simple effects of difficulty level and conditions were performed (Winer, 14). Tests on the simple effects for conditions showed that, for both the easy and the difficult figures, all four conditions were significantly different from one another ($p<.01$). The V-V condition always took the least time and the T-T condition the most. The order of the conditions in terms of increasing time was as follows: V-V T-V V-T T-T. Tests on the simple effects of difficulty level showed that there was not a significant difference in time for the V-V condition. However, the difficult figures took significantly more time for the other three conditions ($p<.01$).

DISCUSSION

The results of this experiment show that the task was relatively easy for both high and low aptitude men. The low aptitude men produced significantly more overall errors than the high. The majority of errors for both groups occurred in the most difficult (T-T) condition. This supports some earlier studies (e.g., Lobb, 9 and Cashdan 10), which reported that the tactual modality working alone, on this type of task, is inferior to the visual modality working alone. It does not, however, support the study by Garvill and Molander (11) which showed that intramodality matching is superior to intermodality matching.

As mentioned earlier, one of the main differences between this and previous experiments is the fact that in this one the time allowed for making the match was left to the discretion of the subject. This was done in order not to impair the operation of the tactile modality, which proceeds successively and more slowly than vision.

The results of the time scores do indeed show that tactile form perception proceeds much more slowly than visual perception. The V-V condition consistently took the least time and the T-T condition always took the most time. Theoretically, the intermodal condition (T-V, V-T) should fall between these two extremes and be approximately equal in terms of time because both include a visual and a tactual component. However, in the experimental situation, the results showed that T-V always took significantly less time than V-T. This difference could be explained by the fact that in the T-V condition the tactual modality examined only one figure, the standard, while the four comparison figures were examined visually. Thus, in the V-T condition four figures had to be explored tactually, which probably resulted in the greater total time for this condition.

In summary, this experiment showed that high aptitude men, as a group, are somewhat more accurate overall than low aptitude men in making both intermodal and intramodal form discriminations. Both groups did equally well on the extremely easy V-V condition and the difference between the two groups was most accentuated on the difficult T-T task.

Not only was the high aptitude group more accurate but these men also took less time to make the match. The data analysis and the graphical profiles of the time scores showed that there was no indication of an interaction between aptitude level and the four conditions. The time scores for both groups increased in the following order: V-V T-V, V-T, T-T. It seems that on this particular task both groups functioned in the same way (there were no interactions between groups and conditions), with the high aptitude men taking less time and making fewer errors.

Chapter 4

EXPERIMENT II

METHOD

Experiment II was a direct extension of Experiment I. The first experiment consisted of a simultaneous discrimination or matching task, whereas Experiment II involved a delayed matching task. The subject had to learn the shape of a figure with one modality and then, after a set delay period, compare it with another form in either the same or a different modality.

The purpose of this experiment was to determine how delay would affect the transfer of information across time—specifically, whether delay would have a differential effect for the two groups of subjects, high vs. low aptitude. Another purpose was to determine whether delay would have a differential effect on the ability to make correct comparisons in the intramodal, as compared to the cross-modal, conditions.

Thirty high aptitude and 30 low aptitude men were divided into three groups of 10 and assigned to a 1-second, 5-second, or 10-second delay condition. The materials used were equivalent to the difficult figures used in Experiment I (Figure 2), but only one comparison figure was used in contrast to the three comparison figures used in Experiment I. Each man received a standard form either visually or tactually, and was instructed to examine the figure until he was satisfied that he could identify it again. The man could study the figure for as long as he wanted and the experimenter recorded the duration of the study time. When he had completed his examination, the standard figure was removed. After the delay period of 1, 5, or 10 seconds, the comparison figure was presented in either the same or a different modality. The man then verbally identified the comparison figure as the "same" or "different," with the experimenter again recording how long he took to respond.

Each subject received four study-match trials under each of the conditions for a total of 16 trials. By random selection, seven of the trials consisted of matched forms, while nine trials consisted of different pairs. The conditions were, again, two intramodal (V-V) + (T-T) and two intermodal (T-V) + (V-T). The order of presentation for both the figures and the conditions was counterbalanced across all of the subjects in each group.

After the completion of the experiment, the men were asked for verbal reports on how they performed the task. Later, all the men (with the exception of two high and three low aptitude men who were unavailable) were asked also to take the Bender-Gestalt test so that the scores on this might be related to their performance on the discrimination task.

RESULTS

The results were analyzed separately for error and time scores. The distribution of total errors for high and low aptitude men as a function of delay and conditions is presented in Table 4. These error scores were tested for significance by an analysis of variance, a summary of which appears in Table 5. Factor A refers to the two groups, Factor B to the three delay levels, and Factor C (which is a repeated measure) to the four conditions. The outcome of this analysis shows a significant main effect for the group

factor. Lows committed significantly more total errors than highs, ($p<.001$). The main effect for delay (B) was not significant, nor were any of the interactions with the delay factor. Evidently, because of the open-ended study times, the delay periods were not long enough to indicate a loss of information.

Table 4

Total Errors for Both Groups: Experiment II

Conditions		Category I Men				Category IV Men			
		Delay (Seconds)			Total	Delay (Seconds)			Total
Standard	Comparison	1	5	10		1	5	10	
Visual	Visual	8	4	3	15	12	10	12	34
Tactual	Visual	7	11	10	28	9	10	10	29
Visual	Tactual	5	8	7	20	13	13	17	43
Tactual	Tactual	10	11	10	31	13	13	16	42

Table 5

Analysis of Variance for Error Scores: Experiment II

Source	*df*	*MS*	*F*	*p*
Between Subjects				
Groups (A)	1	12.16	17.13	<.001
Delay (B)	2	.21	<1	
AB	2	.53	<1	
Error	54	.71		
Within Subjects				
Conditions (C)	3	1.71	2.16	<.10
AC	3	1.57	1.99	NS
BC	6	.41	<1	
ABC	6	.14	<1	
Error	162	.79		

The main effect for conditions (C) was of marginal significance ($p<.10$). Individual comparisons of the pairs of conditions showed only that the T-T condition resulted in significantly more errors than the V-V condition ($p<.01$). All other differences between pairs were not significant.

The mean study and match times for the high and low aptitude men under each of the four conditions are shown in Table 6. An analysis of variance (Table 7) was computed for these data, the appropriate model being a four-factor analysis with repeated measures on the last two factors (the study and match factor, and the four bimodal conditions).

Table 6

Mean Study and Match Times for High and Low Aptitude Subjects: Experiment II

Delay	Study Time (Minutes)				Match Time (Minutes)			
	V-V	T-V	V-T	T-T	V-V	T-V	V-T	T-T
Category I								
1 Second	.36	.94	.53	.92	.11	.22	.31	.32
5 Seconds	.42	.86	.53	.89	.14	.27	.44	.48
10 Seconds	.31	.85	.39	.95	.10	.16	.39	.34
Category IV								
1 Second	.33	.63	.41	.68	.19	.21	.32	.35
5 Seconds	.24	.54	.31	.53	.12	.18	.28	.29
10 Seconds	.23	.54	.27	.52	.13	.16	.34	.32

Table 7

Analysis of Variance of Time Scores: Experiment II

Source	*df*	*MS*	*F*	*p*
Between Subjects				
Group (A)	1	2.03	5.87	<.05
Delay (B)	2	.10	<1	
AB	2	.14	<1	
Error	54	.35		
Within Subjects				
Study-Match (C)	1	10.25	106.72	<.001
AC	1	1.10	11.44	NS
BC	2	.09	<1	
ABC	2	.01	<1	
Error-C	54	.10		
Conditions (D)	3	2.29	109.14	<.001
AD	3	.17	8.29	<.001
BD	6	.00		
ABD	6	.01	<1	
Error-D	162	.02		
CD	3	1.33	82.94	<.001
ACD	3	.07	4.63	<.001
BCD	6	.03	<1	
ABCD	6	.01	<1	
Error-CD	162	.02		

For total times, the analysis of variance shows that the high aptitude men took significantly longer to perform the task than the low aptitude men ($p<.05$). Again, there was no effect for delay (B), and none of the interactions with the delay factor were significant. The time scores in this experiment contrast with the scores in Experiment I in which the low aptitude men took longer to perform the task. This will be discussed further in a later section. As might be expected, there was a significant main effect for the study and match Factor C and it can be seen in Table 7 that study time was significantly greater than match time ($p<.001$).

The main effects and two factor interactions that were significant can best be explained by considering the groups by study-match by conditions (ACD) interaction, which was also significant. The study and match times of the high and low aptitude men as a function of the conditions are shown in Figure 5.

Mean Study-Match Times of Both Groups as a Function of Conditions

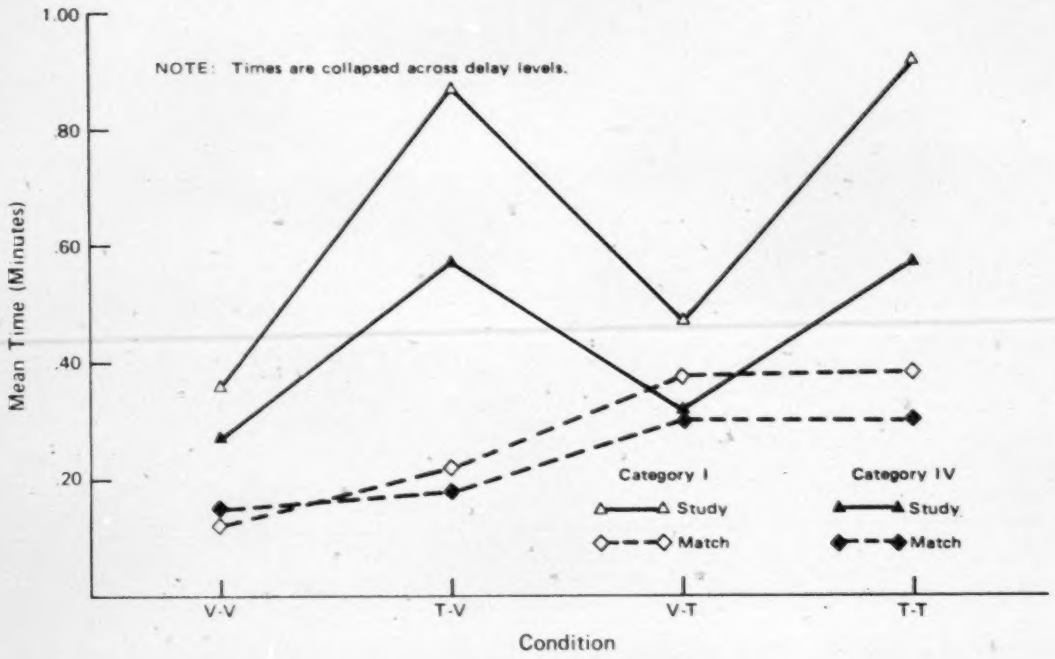


Figure 5

An analysis of the simple effects for the triple interaction yielded the following results. Except for the V-V condition, high aptitude men took significantly more time to study the figures than did low ($p<.01$). There was not a significant difference between highs and lows on the time they took to make the match in any of the conditions. For just the study times, it was found that, for both groups, the tactile study conditions (TV + TT) took significantly longer than the visual study conditions (V-V and V-T) ($p<.001$). The tactile study conditions were not significantly different from each other for either group. The V-T study condition took significantly longer than the V-V study condition ($p<.05$), indicating that the anticipation of a tactual match significantly increased visual study time. Again, there were no subject differences.

The match times followed much the same pattern as the study times. For both high and low aptitude men, the tactual match conditions (V-T and T-T) took significantly longer than both the visual match conditions (V-V and T-V) ($p<.01$). Both groups also showed that there were no significant differences between either the two tactual match conditions or the two visual match conditions.

The main distinction between high and low aptitude people, in terms of these data, seems to be that high aptitude people took significantly more time to study the standard figures in the T-V, V-T, and T-T conditions. Figure 5 shows almost identical graphical profiles for both groups. The differences between the two groups are primarily quantitative, highs taking more study time across all conditions (with the exception of V-V) than lows.

What is clear from all the time data is the relative speed of vision as compared to touch in information processing. As a result, when an experimenter imposes an arbitrary time limit on the parameters of stimulus presentation, he risks biasing his results in favor of the visual modality in discrimination tasks of this kind.

DISCUSSION

The data from Experiment II show that the high aptitude group committed significantly fewer errors than the low aptitude group apparently because they studied the forms significantly longer. Since the study-match sequence was self-paced for both groups, it is clear that the high group was doing something more than the low group in the study phase. In an attempt to discover what kind of study or processing strategies were used that could account for this, the verbal reports of the subjects were examined.

On the basis of these reports, the processing strategies could be divided into two main categories—simple or complex. A simple strategy was operationally defined as one in which the subject reported that he tried merely to form a "picture" or "image" of the standard or study figure. A complex strategy was operationally defined as one in which the subject reported that he either (a) counted angles or points, (b) used verbal mediators, or (c) tried to map out the spatial characteristics of the figure. In a number of cases, a man would report that he used several strategies, which left it to the experimenter, through further questioning, to determine in which major category he would fall. For example, if a man reported that he tried, mainly, to form an image but that he counted on a few but gave up, he would be counted as using a simple strategy. It is obvious that neither of these strategies is all-inclusive nor exclusive of all possible strategies and personal idiosyncrasies. However, verbal reports of what a subject can *remember* doing should (if they exist) give an indication of differences in approach.

The numbers of high and low aptitude men who reported using either a simple or a complex strategy are shown in Table 8. It appears that the majority of the low aptitude men used a simple strategy and the majority of the high aptitude men used a complex strategy. A chi square test that was computed to compare the groups on the strategies was significant ($p<.01$). This indicated that, in this experiment, the reason high aptitude men took more study time and committed fewer errors was that they organized their inputs for more accurate retrieval. It seems likely that it would take longer to count angles or corners and organize spatial characteristics than merely to try to hold a sensory impression of the stimulus.

Table 8

Processing Strategies, Experiment Errors, Bender-Gestalt Errors, and Total Times for Both Groups

Measures (Mean)	Category I Men		Category IV Men	
	Simple (N=6)	Complex (N=22)	Simple (N=19)	Complex (N=10)
Experiment Errors	4.50	2.80	5.32	4.20
Bender Errors	4.60	3.80	12.25	9.70
Total Times	3.35	3.77	2.48	3.22

Additional data to support the existence of differential processing strategies are presented in Table 8. The mean errors for the experimental task and for the Bender-Gestalt test[1] (errors in this test were defined as inaccurate reproductions of the Bender-Gestalt figures), plus the mean total time, were computed for all of the subjects falling within a certain category. Although the differences were not great, they do show that (a) men who used a simple strategy produced more errors in both tasks, and (b) men who used a complex strategy took longer to complete the task.

It is probable that the delay conditions were not long enough to show any differences. In a task that leaves the study time open-ended, more realistic delay periods between the standard and comparison stimuli would be in the range of from 10 to 60 seconds.

From the point of view of intermodal information processing, the present study showed a marked superiority for the visual modality in both speed and accuracy. For both groups on the time scores, and for the high aptitude men on the error scores, the visual study conditions (V-V and V-T) produced the most accurate discrimination or matching in the least time.

The low aptitude men's error scores tended to show a superiority for the visual match conditions (V-V and T-V), possibly because low aptitude men, using inadequate processing strategies, did not adequately encode the visual or tactual information from the standard form. As a result, when the matches were made, the limited information gained during the study portion was not adequate to transfer as accurately to touch as to vision. To interpret, in intermodal form discrimination, the form to be discriminated must be organized and encoded in such a way that the resulting percept will contain the "distinctive features," (Gibson, 12), that are necessary to make it discriminable from similar forms. This percept also has to be transferable across different modalities.

[1] The Bender-Gestalt test was not used in a clinical capacity. The test was scored only on the basis of correct or incorrect reproduction of the Gestalt figures. For a discussion of the clinical use of the Bender-Gestalt test see Loretta Bender, "A Visual Motor Gestalt Test and Its Clinical Use," *Research Monographs*, No. 3, American Orthopsychiatric Association, New York, 1938.

Chapter 5

SUMMARY DISCUSSION

An examination of Experiment I and Experiment II shows that, in general, high aptitude men are significantly better at both a simultaneous and a delayed form discrimination task. In Experiment II there is evidence to indicate that the better functioning of the high aptitude group is due to superior learning or information processing strategies.

Using only time as a dependent measure of proficiency, Experiment I showed that a simple form discrimination task that involved little information processing was performed more quickly by the high aptitude group. On the other hand, a more complex task that required considerable information processing, as in Experiment II, was not performed more quickly by high aptitude men.

High aptitude men performed more slowly than low aptitude men because they took significantly more time to study the standard figure. It is likely that they used the increased study time to develop mediational units that enabled them to make more accurate matches. As a group, the low aptitude men took significantly less study time than the highs, which seems to indicate that they were unwilling or unable to use appropriate processing strategies that might have increased their accuracy.

The error data from both experiments showed that both groups of men were able to successfully integrate information from more than one modality, and there were no interactions between the groups and conditions factors. It was originally thought that if low aptitude people were deficient on a purely sensory-motor level, this would show up in their ability to make intermodal discriminations. A previous study on intersensory development in children by Birch and Lefford (15) reported that the ability to make intersensory judgments improves with age, and that children below seven or eight years of age are much better at making intramodal than intermodal discriminations. Another study, reported by Birch and Belmont (16), showed that brain-damaged children were also better on intramodal than intermodal discriminations. Since there were no significant differences between the high and low aptitude groups on the intermodal vs. intramodal tasks, it seems that any real deficiencies in form discrimination ability between the two groups would exist on a higher order information processing level than the deficiencies reported for younger and brain-damaged people.

In the introduction to this report it was mentioned that some earlier studies on intermodal discrimination were at variance as to whether there is a greater transfer of information from touch to vision or from vision to touch. It is possible that these discrepant findings may have been due to methodological variables. As previously noted, these studies had imposed an arbitrary time limit on both visual and tactual exploration. Since more time is required for tactual than for visual exploration, it is possible that tactual stimuli were never fully encoded, thus resulting in poorer transfer from touch to vision. In the present study, in which the exploration time was left to the discretion of the subject, the time scores clearly showed that much more time was used for tactual exploration than for visual exploration.

The results of Experiment II suggest that a majority of low aptitude men were not using higher order information processing skills. The results of the time scores and interview data indicated that one possible reason low aptitude men produced more errors in the delayed task was because they did not take the time to convert their sensory impressions into mediational units that could be used to make a more accurate match.

Bruner (17) points out that, in a discrimination task, children fall back on global impressions if a task becomes too demanding, and that they have difficulty noticing detailed differences. Further, he states that with increasing age, delayed response patterns become reorganized in terms of verbal-conceptual activity rather than being based primarily on a global-sensory impression. It seems, therefore, that a possible explanation for the findings of this study is that many low aptitude men may not have progressed beyond this earlier stage of development in cognitive abilities.

Dainoff (18) has proposed an information processing model to describe the processes involved in visual and auditory encoding. It could be hypothesized that the same kind of processes are at work in the type of tasks described in this report. As applied to form discrimination tasks, the model would propose that there are two processes at work. First, there is a sensory process that allows the organism to obtain a sensory-perceptual image or representation of the stimulus. This representation deteriorates quickly and is impaired over periods of time as long as one second. However, this representation can be used effectively in comparing simultaneous stimuli, as was done in Experiment I. The second process occurs simultaneously with the first and allows the organism to pick out salient and encodable features of the stimuli so that they can be reorganized into a more permanent memory trace. This reorganization occurs in terms of verbal-mediational or mnemonic units. These units can be rehearsed in short-term memory and consequently are available for comparison with another stimulus. This latter process requires higher order organizational skills which many low aptitude individuals seem to lack.

Two points should be clarified regarding the discussion of Category IV men as a group. First, classification by the AFQT does not guarantee that low aptitude or high aptitude men are homogeneous groups. In fact, the raw data from individuals showed that some Category IV men performed as well as the best Category I men and some Category I subjects performed as poorly as poor Category IV performers. Second, the differences that exist between groups seem to be due to different learning strategies used by the majority of the people within a group rather than the inability of either group to integrate information from more than one modality. Therefore, it would seem possible, through remedial training, to teach marginal aptitude people the skills required to develop higher-order processing strategies that would be beneficial in handling different types of perceptual and cognitive tasks.

One possible approach could be through a program that would include training and practice in the use of mnemonic devices and natural language mediators. Those in such a program could also be taught how to reorganize stimulus inputs into their most salient characteristics to make encoding more efficient. These are the types of skills that are never formally taught, but that most people acquire as part of their educational development. In the case of many Category IV people, it may be that these skills were not fully developed during their school years.

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13. ABSTRACT

This report presents the findings of research that compared high and low aptitude subjects on two form discrimination tasks that required both intramodal and intermodal functioning. In the first experiment, 20 high and 20 low aptitude Army trainees were required to make a simultaneous discrimination of nonsense forms, using vision and touch. The second experiment, with 30 high and 30 low aptitude men, introduced a delay period between the presentation of the standard and comparison stimuli. For the first experiment, results showed that the high aptitude subjects consistently performed more accurately and more rapidly. In the second experiment, low aptitude subjects again committed more errors, but took significantly less study time than the highs. Analysis of verbal reports showed that the majority of the high aptitude men used higher-order processing or learning strategies, which enabled them to make more accurate matches.

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